PIEZOELECTRIC TRANSFORMER FOR FLUORESCENT LAMP

BACK GROUND OF THE INVENTION

The present invention relates to a piezoelectric transformer, and more particular to the piezoelectric transformer for a fluorescent lamp including a piezoelectric block having smaller electrodes at the center region of each sides than that at corner region to minimize the stress at the center region of the piezoelectric block in order to use for general fluorescent lamp.

Since $BaTiO_3$ has been introduced at the mid-1940s as a piezoelectric seramic material, this seramic material having the good piezoelectric characteristics, such as $Pb(Zr,Ti)O_3$ (PZT), is useful for the electric device. The PZT which is the solid solution of $PbZrO_3$ and $PbTiO_3$ is the 2-element based perovskite structure having the good piezoelectric characteristics. Recently, 3-element based perovskite has been studied to vary easily the composition of the 2-element based perovskite and to improve the piezoelectric characteristics. For example, $Pb(Mg,Nb)O_3$-$Pb(Zr,Ti)O_3$, $Pb(Mg,Ta)O_3$-$Pb(Zr,Ti)O_3$, and $Pb(Mn,Nb)O_3$-$Pb(Zr,Ti)O_3$ are developed as the 3-element based complex perovskite compound.

FIG.1 shows a applicable example of the piezoelectric material, i.e., a band pass filter for the amplitude modulation. Where, FIG.1A is a plan view of the band pass filter and FIG.1B is a sectional view along the line A-A of FIG.1A. As shown in figures, the band pass filter comprises a piezoelectric block of hexahedron shape having electrodes on the upper and lower faces. At this time, the electrodes

on the upper face are input/output electrodes 3 and 5 and the electrode on lower face is a common electrode 7.

When the AC voltage corresponding to the resonant frequency is supplied to the input electrode 3, the electric signal is converted into the strong mechanical vibration near the input electrode and the converted vibration is transmitted to the output electrode. As a result, the voltage proportional to the resonant frequency is outputted from the output electrode 5.

The piezoelectric material has been introduced at end-1910s and applied to the various electronic device such as a high voltage generator, an ultrasonic generator, sound facilities, a 45.5KHz IF filter for AM radio and a 10.7MHz filter for FM radio, a communication device, and the various sensors. Further, this piezoelectric material has been used for a resonator or filter for communication device, an inverter of a cold cathode tube for a backlight of a liquid crystal display. In addition, the piezoelectric transformer used for the general inverter is also introduced.

The structure of the typical transformer composed with the piezoelectric material is shown in FIG.2. Where, FIG.2A is a perspective view and FIG.2B is a sectional view. This transformer is Rosen type transformer having vibrations mode in the thickness and length directions. As shown in figures, the transformer is polarized in the thickness direction at the input electrode region on a part of the upper and lower faces. In the output electrode region, further, it is polarized in the length direction. When the AC voltage corresponding to the resonant frequency is supplied to the input electrodes 3a and 3b to raise the voltage of the piezoelectric transformer, the supplied electric signal is converted into the strong mechanical

vibration of the length direction near the input electrodes and then transmitted to the output electrode to generate the longitudinal vibration. Then the longitudinal mechanical vibration is outputted from the output electrode 5 as the raised high voltage having the high frequency that is identified with the frequency of the voltage supplied to the input electrode.

At this time, the raise of the voltage at the output electrode is maximized when the frequency of the input voltage is identified with the mechanical vibration frequency at the output electrode. Further, the voltage-raise ratio of the piezoelectric transformer, which is dependant upon the load impedance of the material, is maximized when the relatively higher load impedance is applied to the output electrode. In case of the lower load impedance, the voltage raise ratio is less than several tens times.

When the piezoelectric transformer is used for the lamp such as the cold cathode tube and the fluorescent lamp, it has the different load impedance in accordance with the kind of the lamp. However, if the piezoelectric is made under the optimum fabrication condition, the high voltage-raise ratio can be maintained under the condition of the lower load impedance. In the normal state that the impedance is decreased after lighting, further, the voltage-raise ratio can suitably be maintained so that the piezoelectric transformer can be used for the lamp such as the cold cathode tube and the fluorescent lamp.

Recently, the piezoelectric transformer having the outline vibration mode shown in FIG.3 is also introduced. As shown in FIG.3, the piezoelectric transformer of the outline vibration mode has the structure similar with that of the band pass filter shown in FIG. 1 except the shape of the electrodes. That is, the

electrode in FIG.3 is the circular shape, while the rectangular shape in FIG.1. In this piezoelectric transformer, the output electrode 5 is disposed on the upper face of the piezoelectric block 1 at the predetermined distance from the input electrode 3 and the common electrode 7 is disposed on the lower face of the piezoelectric block 1.

When the voltage is supplied to the piezoelectric block 101 through the input electrode 3, the electric signal is converted into the mechanical vibration directed to the side portion from the central portion of the piezoelectric block 1 and then the signal proportional to the mechanical vibration is outputted though the output electrode 5. This piezoelectric transformer may be used for the liquid crystal display of notebook computer and the low-consumption transformer.

There, however, is a problem that the piezoelectric material is not applicable to the high power transformer. Since the Rosen or the deposited Rosen type piezoelectric transformer (U.S patent NO. 6,037,706) has the complex structure and outputs the low output signal, it is not applicable to the fluorescent lamp. In the outline vibration mode-piezoelectric transformer, the deposited structure of the piezoelectric material should be studied because of the problem of the material. The electrodes of the circular and rectangular shapes in the outline vibration mode-piezoelectric transformer is disclosed in 'Design of Fluorescent lamp with PFC using a power piezoelectric transformer, Sung Jin Choi, IEEE(1998. 2. 15), P1141' . In this transformer, however, there is a problem that the out signal is low.

Further, there is a problem that the stress is maximized in a part of the piezoelectric block so that the piezoelectric device may be destroyed and the

efficiency thereof may be deteriorated, when the electric signal is converted into the mechanical vibration.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a piezoelectric transformer in which the electrode at the low vibration region of the piezoelectric block, the central region of the sides, is minimized to eliminate the heat caused by the stress and prevent the damage of the piezoelectric block.

In order to achieve the object, in the piezoelectric transformer of the present invention the size of the electrode at the stress generation region on the upper face of the piezoelectric block is decreased to minimize the heat caused by the stress. The stress is chiefly generated near the central region of each sides of the piezoelectric block. By minimizing the size of the electrode at this region, thus, the stress is also minimized and as a result this piezoelectric transformer is applicable to the high power transformer. For the minimized electrode, the electrode can be formed in the diamond shape or the cross shape. The shape of the electrode can be formed in the various shapes, without the limitation.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG.1 is a view showing the structure of the conventional band pass filter using the piezoelectric material.

FIG.2 is a view showing the structure of the conventional piezoelectric

transformer of Rosen type using the piezoelectric material.

FIG.3 is a view showing the structure of the conventional piezoelectric transformer of outline vibration mode using the piezoelectric material.

FIG.4 is a view showing the structure of the piezoelectric transformer for the fluorescent lamp according to one embodiment of the present invention.

FIG.5 is a view showing the mechanical vibration when the voltage is supplied to the piezoelectric transformer for the fluorescent lamp.

FIG.6 is a view showing the structure of the piezoelectric transformer for the fluorescent lamp according to other embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

In general, the back light used for the liquid crystal display device has the Rosen type-piezoelectric transformer. This Rosen type piezoelectric transformer used as the lighting device of the cold cathode tube has the high voltage and low current characteristics so that it is not applicable to the general fluorescent lamp. During lighting, the impedance of the general fluorescent lamp is less than few KΩ, while the impedance of the cold cathode tube is approximately 80-100KΩ. Thus, the impedance of the general fluorescent lamp is far less than that of the cold cathode tube.

This invention provides the piezoelectric transformer applicable to the general fluorescent lamp. To fabricate this piezoelectric transformer, in this invention, the electrodes have the different structure from that of the conventional piezoelectric transformer. By this electrode structure, the maximum stress is

generated at the different region from that of conventional piezoelectric transformer and as a result the desired current and voltage may be obtained.

Hereinafter, the piezoelectric transformer according to the present invention will be described in detail, accompanying drawings.

FIGs. 4 are view showing the piezoelectric transformer of the present invention. Where FIG. 4A is a plan view and FIG.4B is a sectional view. As shown in figures, the piezoelectric transformer of the present invention comprises the piezoelectric block 101 having the hexahedral shape, the input/output electrodes 103 and 105 on the upper face of the piezoelectric block 101, and the common electrode 107 on the lower face of the piezoelectric block 101.

The input electrode 103 is substantially formed in the rhombic shape or the diamond shape and separated from the output electrode 105 in the predetermined distance. The common electrode 107 is integrally formed on at least a part of the lower face of the piezoelectric block 101.

In this piezoelectric transformer, when the electric signal is inputted through the input electrode 103 and the common electrode 107, the electric signal is converted into the mechanical vibration of the outline vibration mode within the piezoelectric block 101 and then the signal proportional to the mechanical vibration is outputted through the output electrode 105.

As shown the dash double-dot line of FIG.5, when the voltage is supplied, the resultant vibration is maximized at the corner region of the piezoelectric block, while minimized at the central region of each sides. In the figure, an arrow in the corner region indicates the degree of the vibration in the piezoelectric block 101. At this time, the degree of the vibration is dependant upon the piezoelectric

material and the supplied voltage.

Since the mechanical vibration is maximized at the corner region of the piezoelectric block 101 and minimized at the central region (indicated as P in the figure) of the sides, as shown above, the maximum stress is acted at the central region of the piezoelectric block 101 and the second high stress is acted at the central region of the sides of the piezoelectric block 101. By this stress, therefore, the heat is generated at the central region of the sides, so that the piezoelectric block may be damaged.

When the electric signal is converted into the mechanical vibration, the vibration is strongly generated at the input/output electrodes. Thus, if the size of the electrode at the central region P of the sides is decreased, the degree of the vibration is also decreased. As a result, the less heat is generated at this region. At this time, the size ratio of the input electrode 103 and the output electrode 105 is preferably 1:1.5-1:3.14.

In order to form the electrode having above size ratio, the input electrode 103 is formed in the diamond shape. Thus, the area between the input and output electrodes 103 and 105 where the electrode is not disposed is extended near the central region P of the sides of the piezoelectric block 101 so that the size of the electrode is decrease at the region P.

In case where the input electrode 103 is formed in the diamond shape as shown above, the energy conversion efficiency is improved and the capacitance is increased to decrease the impedance at the output, because the electro-mechanics coupling coefficient Kp in the radius direction is higher than the coupling coefficient K31 in the length direction. As a result, the output power may be

increased. Further, the raise ratio of the voltage is decreased so that this piezoelectric transformer is applicable to the lighting of the fluorescent lamp having the low impedance in case of the input electrode 103 of the diamond shape.

It is not necessary to limit the shape of the input electrode 103 as the diamond shape. In other word, the electrode can be formed in any shape that the stress can be decreased in accordance with the decrease its size at the central region P of the sides of the piezoelectric block 101 to minimize the heat generation.

As shown in FIG.4B, the common electrode 107 is integrally formed at a part on the lower surface of the piezoelectric block 101 and the input/output electrodes 103 and 105 are connected to the outer circuit (not shown in figure). In this case, the noise may be inputted from the outer circuit through the common electrode 107. In order to solve this problem, the common electrode 107 can be made in a plurality of isolated electrodes as shown in FIG. 6A. By this isolation of the common electrode 107, the noise cannot be inputted to the piezoelectric transformer from the outer circuit. In general, the common electrode 207 is formed in the different shape from those of the input electrode 203 and the output electrode 205, as shown in FIG.6A. However, the common electrode 207 may be formed in the same shape with the input electrode 203 and the output electrode 205 as shown in FIG.6B.

In the piezoelectric transformer of the present invention, as described above, the electrode at the central region of each sides of the piezoelectric block has smaller size than that of the electrode at the corner region. At this time, the shape of the electrode is not necessary to be specified. The input electrode can be

formed in the various shapes such as the diamond, rhombic, or cross shapes.

As described above, the size of the electrode is minimized at the maximum stress generating area to decrease the stress. Thus, when the piezoelectric transformer is used for the high voltage transformer, the damage of the piezoelectric block or deterioration of the efficiency caused by the heat can be prevented.

While the invention has been described in its preferred embodiments, this should not be construed as limitation on the scope of the present invention. Accordingly, the scope of the present invention should be determined not by the embodiments illustrated, but by the appended claims and their legal equivalents.